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CHARLES J. MCMAHON INTERFACIAL SEGREGATION AND EMBRITTLEMENT SYMPOSIUM

AFOSR: F49620-02-1-0064

The symposium took place during the annual meeting of TMS in Seattle, Washington, February 18–February 21, 2002. The program of the symposium is enclosed with this report.

The support provided by this grant was used to cover travel and subsistence of the following invited foreign speakers.

Professor John F. Knott, Department of Materials Science and Engineering, Birmingham University, England (\$1,119).

Professor David Embury, Department of Materials Science and Engineering, McMaster University, Hamilton, Canada (\$395)

Professor Manfred Ruhle, Max-Planck-Institut für Metalforschung, Stuttgart, Germany (\$603)

Dr. Wilfried Sigle, Max-Planck-Institut für Metalforschung, Stuttgart, Germany (\$768)

Dr. Pavel Lejcek, Institute of Physics, Academy of Sciences of the Czech Republic, Prague, Czech Republic (\$1,079)

Dr. Christian Elsaesser, Fraunhofer Institute, Freiburg, Germany (\$1,036)

Charles J. McMahon Interfacial Segregation and Embrittlement Symposium: Grain Boundary Segregation and Fracture in Steels

Sponsored by: ASM International: Materials Science Critical Technology Sector, Structural Materials Division, Materials Processing & Manufacturing Division, Jt. Mechanical Behavior of Materials, Jt. Computational Materials Science & Engineering, Texture & Anisotropy Committee

Program Organizers: Vaclav Vitek, University of Pennsylvania, Department of Materials Science and Engineering, Philadelphia, PA 19104 USA; Clyde Briant, Brown University, Division of Engineering, Providence, RI 02912 USA; Harvey D. Solomon, General Electric Company, Research & Development Center, Schenectady, NY 12309 USA

Monday PM Room: 307-308
February 18, 2002 Location: Washington State Convention & Trade Center

Session Chairs: Clyde Briant, Brown University, Div. of Eng., Providence, RI 02912 USA; Vasek Vitek, University of Pennsylvania, Dept. of Matls. Sci. & Eng., Philadelphia, PA 19104 USA

2:00 PM Keynote

Embrittlement Phenomena: Where Have We Been, and Where Are We Going?: *Charles J. McMahon*¹; ¹University of Pennsylvania, Dept. of Matls. Sci. & Eng., 3231 Walnut St., Philadelphia, PA 19104 USA

2:35 PM Invited

Industrial Experiences in Relation to Intergranular Cohesion of Steels: *Hiroo Ohtani*¹; Masaaki Igarashi¹; ¹Sumitomo Metal Industries, Ltd., Corp. Rsrch. Labs., 1-8 Fuso-cho, Amagasaki, Hyogo 660-0891 Japan

3:10 PM Invited

Segregation Intergranular Fracture and Limits to Formability in Re-Phosphorised Steels: *David Embury*¹; Kevin Boyle¹; ¹McMaster University, Dept. of Matls. Sci. & Eng., 1280 Main St. W., Hamilton, Ontario L8S 4L7 Canada

3:45 PM Invited

Effects of Impurity-Element Segregation on Fracture Toughness and Fatigue-Crack Propagation in a 2.25Cr1Mo Steel: *John Frederick Knott*¹; *Aminul Islam*¹; Paul Bowen¹; ¹The University of Birmingham, Sch. of Eng., Elms Rd., Birmingham, Edgbaston B15 2TT UK

4:20 PM

Quench Embrittlement: A Recently Recognized Mechanism of Intergranular Embrittlement in As-Quenched High-Carbon Steels: *George Krauss*¹; David K. Matlock¹; ¹Colorado School of Mines, Adv. Steel Rsrch. Ctr., Golden, CO 80401 USA

4:40 PM

Anomalous Fracture Behavior of AISI 4340 Steels Treated at Different Solution Annealing Temperatures: *Jaroslav Pokluda*¹; ¹Brno University of Technology, Inst. of Physl. Eng., Technicka 2, Brno CZ-616 69 Czech Republic

5:00 PM

Boronizing on Impurity Controlled Steels: C. Bindal²; A. H. Ucisik¹; ¹Sakarya University, Dept. of Metall. & Matls. Eng., Adapazari-Sakarya Turkey; ²Bogazici University, Dept. of Matls. Inst. of Biomed. Eng., Saribal S. 40, Ortakoy-Istanbul 80840 Turkey

Charles J. McMahon Interfacial Segregation and Embrittlement Symposium: Theory of Segregation and Fracture

Sponsored by: ASM International: Materials Science Critical Technology Sector, Structural Materials Division, Materials Processing & Manufacturing Division, Jt. Mechanical Behavior of Materials, Jt. Computational Materials Science & Engineering, Texture & Anisotropy Committee

Program Organizers: Vaclav Vitek, University of Pennsylvania, Department of Materials Science and Engineering, Philadelphia, PA 19104 USA; Clyde Briant, Brown University, Division of Engineering, Providence, RI 02912 USA; Harvey D. Solomon, General Electric Company, Research & Development Center, Schenectady, NY 12309 USA

Tuesday AM Room: 307-308
February 19, 2002 Location: Washington State Convention & Trade Center

Session Chairs: David N. Seidman, Northwestern University, Dept. of Matls. Sci. & Eng., Evanston, IL USA; Pavel Lejcek, Academy of Sciences of the Czech Republic, Inst. of Phys., Prague Czech Republic

8:30 AM Invited

Computational Materials Science Approach to Interfacial Segregation and Embrittlement: *Arthur J. Freeman*¹; ¹Northwestern University, Dept. of Phys. & Astron., 2145 N. Sheridan Rd., Evanston, IL 60208 USA

9:05 AM Invited

Interfacial Adhesion and Structure of Grain Boundaries in bcc Transition Metals with Segregated Interstitial Impurities: *Christian Elsässer*¹; Rebecca Janisch¹; Thorsten Ochs¹; ¹Max-Planck-Institut für Metallforschung, Seestr. 92, C-70174, Stuttgart Germany

9:40 AM Invited

Impurity-Induced Decohesion: *John L. Bassani*¹; ¹University of Pennsylvania, Mech. Eng. & Appl. Mech., 297 Towne Bldg., 220 S. 33rd. St., Philadelphia, PA 19104-6315 USA

10:15 AM

Brittle Fracture and the Breaking of Atomic Bonds: *Peter Gumbsch*¹; ¹Max-Planck-Institut für Metallforschung, Seestrasse 92, 70174 Stuttgart Germany

10:35 AM

A Universal Mechanism of Brittle Compressive Failure: *Erland M. Schulson*¹; Carl E. Renshaw¹; ¹Thayer School of Engineering, Dartmouth College, Hanover, NH 03755 USA

10:55 AM

Segregation of Phosphorus Atoms to Grain Boundaries in Ferritic Steels under Neutron Irradiation: *Alexander V. Barashev*¹; Yury N. Osetsky¹; David J. Bacon¹; ¹The University of Liverpool, Dept. of Eng., Matls. Sci. & Eng., Liverpool L69 3GH UK

11:15 AM

Interaction of Grain Boundaries with Point Defects in fcc Metals: *Akira Suzuki*¹; Yuri Mishin¹; ¹George Mason University, Sch. of Computl. Scis., 4400 University Dr., MSN 5C3, Fairfax, VA 22030 USA

11:35 AM

Atomistic Simulations of Segregation of Alloying Elements to a Grain Boundary in bcc Fe: *Diana Farkas*¹; Renata N. Nogueira²; Margarita Ruda³; ¹Virginia Tech, Dept. of Matls. Sci. & Eng., Blacksburg, VA 24060 USA; ²USP, Escola Politecnica, Sao Paulo Brazil; ³CNEA, Centro Atomico Bariloche, Bariloche Argentina

Charles J. McMahon Interfacial Segregation and Embrittlement Symposium: New Methods for Study of Segregation and Fracture I

Sponsored by: ASM International: Materials Science Critical Technology Sector, Structural Materials Division, Materials Processing & Manufacturing Division, Jt. Mechanical Behavior of Materials, Jt. Computational Materials Science & Engineering, Texture & Anisotropy Committee

Program Organizers: Vaclav Vitek, University of Pennsylvania, Department of Materials Science and Engineering, Philadelphia, PA 19104 USA; Clyde Briant, Brown University, Division of Engineering, Providence, RI 02912 USA; Harvey D. Solomon, General Electric Company, Research & Development Center, Schenectady, NY 12309 USA

Tuesday PM Room: 307-308
February 19, 2002 Location: Washington State Convention & Trade Center

Session Chairs: Gregory M. Olson, Northwestern University, Evanston, IL 60208 USA; John L. Bassani, University of Pennsylvania, Dept. of Mech. Eng., Philadelphia, PA 19104 USA

2:00 PM Invited

Advanced Analytical Electron Microscopy Studies of Segregation in Metals and Ceramics: *Manfred R. Hlel*¹; ¹Max-Planck-Institut f. Metallforschung, Seestr. 92, Stuttgart 70174 Germany

2:35 PM Invited

Nanoscale Studies of Segregation at Heterophase Interfaces: *David N. Seidman*¹; Dieter Isheim¹; Jason T. Sebastian¹; ¹Northwestern University, Matls. Sci. & Eng., 2225 N. Campus Dr., Matls. & Life Scis. Bldg., Evanston, IL 60208-3108 USA

3:10 PM Invited

A New Method to Predict the Enthalpy and Entropy of Solute Segregation at Individual Grain Boundaries: *Pavel Lejcek*¹; Siegfried Hofmann²; ¹Institute of Physics, Acad. Sci. Czech Rep., Na Slovance 2, Praha 8 182 21 Czech Republic; ²Max-Planck-Institut für Metallforschung, Seestr. 92, Stuttgart 70174 Germany

3:45 PM

Segregation of Impurities to the Sigma 5 (310)/[001] STGB and the Influence to the Grain Boundary Structure: *Juergen M. Plitzko*¹; Geoffrey H. Campbell¹; Wayne E. King¹; Stephen M. Foiles²; ¹Lawrence Livermore National Lab, Chem. & Matl. Sci., 7000 E. Ave., MS L-370, Livermore, CA 94550 USA; ²Sandia National Laboratories, Computl. Matls. Sci. Dept., Albuquerque, NM 87185-1411 USA

4:05 PM

Effects of Segregation on the Interfacial Fracture Energy: *W. W. Gerberich*¹; J. M. Jungk¹; J. W. Hoehn²; ¹University of Minnesota, Matls. Sci. & Eng., Minneapolis, MN USA; ²Seagate Technology, Bloomington, MN USA

4:25 PM

Crystal Orientation Examination of Crack Propagation of the Haz of 1 1/4 Cr-1/2 Mo Steel: *Shig Saimoto*¹; Charles H.J. Orchard¹; Shaotang Cao¹; ¹Queen's University at Kingston, Matls. & Metall. Eng., Nicol Hall, Union St., Kingston, Ontario K7L 3N6 Canada

4:45 PM

Structural Studies on Segregation of Na in Sigma 3 Boundries of Si Found in Na-Modified Al-Si Eutectic Alloy: *Mohammad Shamsuzzoha*¹; ¹University of Alabama, SOMED, Tuscaloosa, AL 35487 USA

5:05 PM

Nonequilibrium Grain Boundary Segregation in Austenitic Stainless Steels Induced by Vacancy Flow and Chemical Binding: *Edward P. Simonen*¹; Dan J. Edwards¹; Stephen M. Bruemmer²; ¹PNNL, Matls., PO Box 999, MS P8-15, Richland, WA 99352 USA; ²PNNL, Matls., PO Box 999, MS P8-16, Richland, WA 99352 USA

5:25 PM

Crack Tip Plasticity in Copper Bicrystals: *Jin Yu*¹; J. W. Cho¹; ¹Korea Advanced Institute of Science and Technology, Ctr. for Elect. Pkgg. Matls. (CEPM) Korea

Charles J. McMahon Interfacial Segregation and Embrittlement Symposium: New Methods for Study of Segregation and Fracture II

Sponsored by: ASM International: Materials Science Critical Technology Sector, Structural Materials Division, Materials Processing & Manufacturing Division, Jt. Mechanical Behavior of Materials, Jt. Computational Materials Science & Engineering, Texture & Anisotropy Committee

Program Organizers: Vaclav Vitek, University of Pennsylvania, Department of Materials Science and Engineering, Philadelphia, PA 19104 USA; Clyde Briant, Brown University, Division of Engineering, Providence, RI 02912 USA; Harvey D. Solomon, General Electric Company, Research & Development Center, Schenectady, NY 12309 USA

Wednesday AM Room: 307-308
February 20, 2002 Location: Washington State Convention & Trade Center

Session Chairs: Hiroo Ohtani, Sumitomo Metal Industries, Corporate Rsrch. Labs., Amagasaki Japan 660-0891; Christian Elsässer, Max-Planck-Institut für Metallforschung, Institut für Werkstoffwissenschaft, D-70174 Stuttgart Germany

8:30 AM Invited

The Relationship between the Onset of Plastic Flow in Nearly Perfect Silicon Samples and the Brittle to Ductile Transition:

*David P. Pope*¹; M. Khantha¹; Robert H. Folk¹; Vaclav Vitek¹; ¹University of Pennsylvania, Matl. Sci. & Eng., Irsm Bldg., 3231 Walnut St., Philadelphia, PA 19104 USA

9:05 AM Invited

Effects of Segregation in Cu and Ni₃Al upon Impact Fracture: An Ultra-High Vacuum Study with Local Probe Scanning Auger/Scanning Electron Microscopy: *Jeff Th. De Hosson*¹; D. van Agterveld¹; G. Palasantzas¹; ¹University of Groningen,

Dept. of Appl. Phys., Nijenborgh 4, Groningen 9747 AG The Netherlands

9:40 AM

Segregation in PdO/Pd Alloy Systems: Matthew Augustine¹; Heng Zhang¹; *Harris L. Marcus*¹; ¹University of Connecticut, Inst. of Matls. Sci., Storrs, CT 06269-3136 USA

10:00 AM

Effect of Solutes on Grain Boundary Sliding in Aluminum: *J. S. Vetrano*¹; C. H. Henager¹; R. J. Kurtz¹; R. G. Hoagland¹; V. Gertsman¹; ¹Pacific Northwest National Laboratory, Richland, WA 99352 USA

10:20 AM

Surface Segregation in an Al-4.2At%Ag Alloy: *Robert W. Hyland*¹; H. K. Lee²; H. I. Aaronson³; P. P. Wynblatt³; ¹KB Alloys, Inc., R&D/Tech., 220 Old W. Penn Ave., Box 53, Robeson, PA 19551 USA; ²International Business Machines Corporation, Gen. Tech. Div., Essex Junction, VT 05452 USA; ³Carnegie Mellon University, MSE, Pittsburgh, PA 15213 USA

10:40 AM

The Effect of Impurities on Phase Transformation Kinetics: *Robert C. Pond*¹; Steven Celotto¹; ¹University of Liverpool, Dept. of Eng., Matls. Sci. & Eng., Brownlow Hill, Liverpool L69 3BX UK

11:00 AM

Segregation, Ordering Effects and Relaxations at Surfaces and Interfaces of the Cu-Au System: *Hariton Michael Polatoglou*¹; Anthoula Maidou¹; ¹Aristotle University of Thessaloniki, Phys. Dept., Gr-54006 Thessaloniki Greece

11:20 AM

Neutron Irradiation-Induced Non-Equilibrium Intergranular Segregation: Segregation Capability vs. Kinetics: *Jun Kameda*¹; Yutaka Nishiyama²; Tamara E. Bloomer³; ¹Iowa State University, Ames Lab., Ames, IA 50011 USA; ²Japan Atomic Energy Research Institute, Tokai, Ibaraki 319 Japan; ³US Nuclear Regulatory Commission, Washington, DC 20555 USA

11:40 AM

Temperature and Stoichiometry Effects on Grain Boundary Structure and Cohesion in NiAl: Xuepeng Xie¹; *Yuri Mishin*¹; ¹George Mason University, Sch. of Computl. Scis., 4400 University Dr., MSN 5C3, Fairfax, VA 22030 USA

Charles J. McMahon Interfacial Segregation and Embrittlement Symposium: The Effect of Segregation on Environmental Cracking

Sponsored by: ASM International: Materials Science Critical Technology Sector, Structural Materials Division, Materials Processing & Manufacturing Division, Jt. Mechanical Behavior of Materials, Jt. Computational Materials Science & Engineering, Texture & Anisotropy Committee

Program Organizers: Vaclav Vitek, University of Pennsylvania, Department of Materials Science and Engineering, Philadelphia, PA 19104 USA; Clyde Briant, Brown University, Division of Engineering, Providence, RI 02912 USA; Harvey D. Solomon, General Electric Company, Research & Development Center, Schenectady, NY 12309 USA

Wednesday PM Room: 307-308

February 20, 2002 Location: Washington State Convention & Trade Center

Session Chairs: Harvey B. Solomon, General Electric, Dept. of Matls. Sci. & Eng., Schenectady, NY USA; David L. Pope, University of Pennsylvania, Dept. of Matls. Sci. & Eng., Philadelphia, PA 19104 USA

2:00 PM Invited

Hydrogen Segregation at Interfaces and its Role in Embrittlement: *Howard K. Birnbaum*¹; ¹University of Illinois, Matls. Rsrch. Lab., Urbana, IL 61820 USA

2:35 PM Invited

Effects of Grain Boundary Chemistry and Microstructure on the Intergranular Stress Corrosion Cracking of an Al-Mg Alloy: *Russell H. Jones*¹; Donald R. Baer¹; Michael J. Danielson¹; Valery Y. Gertsman¹; John S. Vetrano¹; Charles F. Windisch¹; ¹Pacific Northwest National Laboratory, Matls. Scis., PO Box 999, Richland, WA 99352 USA

3:10 PM

High Temperature Strength of Two Cryomilled Aluminum Alloys: B. Dehiya¹; K. Tsuchiya²; *J. R. Weertman*¹; ¹Northwestern University, Matls. Sci. & Eng., Evanston, IL 60208 USA; ²Toyohashi University of Technology, Production Sys. Eng., Toyohashi, Aichi 441 Japan

3:30 PM Invited

Grain Boundary Segregation and Precipitation on Intergranular Stress Corrosion Cracking of Austenitic Stainless Alloys in High-Temperature Water Environments: *Stephen Michael Bruemmer*¹; ¹Pacific Northwest National Laboratory, Matls. Interfaces & Characterization, PO Box 999, Richland, WA 99352 USA

4:05 PM

Analysis of Hydrogen-Induced Decohesion at a Particle/Matrix Interface: *Petros Sofronis*¹; Yueming Liang¹; ¹University of Illinois at Urbana-Champaign, Dept. of Theoretl. & Appl. Mech., 216 Talbot Lab., 104 S. Wright St., Urbana, IL 61801 USA

4:25 PM

On the Correlation between Grain Boundary Segregation, Faceting and Embrittlement in Bi Doped Copper: *Wilfried Sigle*¹; Li-Shin Chang²; Wolfgang Gust¹; Manfred Rühle¹; ¹Max-Planck-Institut fuer Metallforschung, Seestrasse 92, D-70174 Stuttgart Germany; ²National Chung-Hsing University, 250, Kuo-Kuang Rd., 402 Taichung Taiwan

4:45 PM

Corrosion and Stress Corrosion Cracking of Al-Mg Alloys: *Clyde Briant*¹; Sharvan Kumar¹; Ping Wang¹; Zhengfu Wang¹; ¹Brown University, Div. of Eng., 182 Hope St., Providence, RI 02912 USA

5:05 PM

On the Stabilization of Grain Boundaries by Solute Segregation: *Reiner Kirchheim*¹; ¹Universität Göttingen, Inst. f. Materialphysik, Hospitalstr. 3-7, Göttingen D-37073 Germany

Charles J. McMahon Interfacial Segregation and Embrittlement Symposium: Design of New Materials

Sponsored by: ASM International: Materials Science Critical Technology Sector, Structural Materials Division, Materials Processing & Manufacturing Division, Jt. Mechanical Behavior of Materials, Jt. Computational Materials Science & Engineering, Texture & Anisotropy Committee

Program Organizers: Vaclav Vitek, University of Pennsylvania, Department of Materials Science and Engineering, Philadelphia, PA 19104 USA; Clyde Briant, Brown University, Division of Engineering, Providence, RI 02912 USA; Harvey D. Solomon, General Electric Company, Research & Development Center, Schenectady, NY 12309 USA

Thursday AM Room: 307-308
February 21, 2002 Location: Washington State Convention & Trade Center

Session Chairs: John Knott, University of Sheffield England; David Embury, McMaster University, Matls. Sci. & Eng., Hamilton, Ontario L8S 4L7 Canada

8:30 AM Invited

The Electrochemical Fatigue Sensor-Development Update: Y. F. Li¹; J. Wang¹; M. Wang¹; A. Witney¹; J. DeLuccia¹; *Campbell Laird*¹; ¹University of Pennsylvania, Dept. of Matls. Sci. & Eng., 3231 Walnut St., Philadelphia, PA 19104 USA

9:05 AM Invited

Advanced Metal Science Based on Nano-Metallurgy: *Kenji Abiko*¹; ¹Tohoku University, Inst. for Matls. Rsrch., 2-1-1 Katahira, Aoba, Sendai, Miyagi 980-8577 Japan

9:40 AM Invited

Grain Boundary Engineering for Alleviating Weld Sensitization and Stress Corrosion Cracking in Nickel-Based Alloys: *Gino Palumbo*¹; ¹Integran Technologies, Inc., 1 Meridian Rd., Toronto, Ontario M9W 4Z6 Canada

10:15 AM Invited

Materials by Design: Quantum Steel: *Gregory B. Olson*¹; ¹Northwestern University, Dept. of Matls. Sci. & Eng., 2225 N. Campus Dr., Evanston, IL 60208 USA

10:50 AM

Grain-Boundary Segregation of Trace Elements in Iridium Alloys and Effects on Mechanical Properties: *E. P. George*¹; L. Heatherly¹; C. T. Liu¹; ¹Oak Ridge National Laboratory, Metals & Cer. Div., 1 Bethel Valley Rd., PO Box 2008, Oak Ridge, TN 37831-6093 USA

11:10 AM

Failure Mechanisms of Thermal Barrier Coatings-Effect of Alloying Elements and Impurities: *Jeff Pfaendtner*¹; Irene Spitsberg¹; ¹GE Aircraft Engines, Matls. & Proc. Eng. Dept., One Neumann Way, MD M89, Cincinnati, OH 45215 USA

11:30 AM

Evolution of Grain Boundary Planes in Grain Boundary Engineering: *Christopher Schuh*¹; Mukul Kumar¹; Wayne E. King¹; Lan Nguyen¹; ¹Lawrence Livermore National Laboratory, Matls. Sci. & Tech., 7000 East Ave., L-350, Livermore, CA 94550 USA